Table S1. Influenza pandemic, regional epidemic, and epizootic database summary (1500-2018).

Influenza outbreak start year	No.# of WHO regions cited	WHO regions confirmed in reviews &/or cited publications (AFR, AMR, SEAR, EUR, EMR, WPR)	Outbreak origin (WHO regions)	Outbreak Origin (country, region)	Continents, Regions, Countries detailed in reviews and citations (truncated view)	Outbreak category (± concurrent epizootics, zoonosis)	Outbreak category (P, E)	Outbreak category (A or B)	Concurrent Epizootic / Zoonosis confirmed in reviews &/or citations	Number of reviews detailing outbreak (N)	Number of review-cited publications confirming outbreak relevant info. (N)	Review #1	Review #3	Review #4	Review #2	Review #5	Review #6	Review #7
1510	2	AFR, EUR	AFR/EMR?	Africa	Africa, Europe, Malta, Baltic States	P	P	A		5	5	P-1510	P-1510	P-1510	P?-1510		P?-1510	
1551	1	EUR	EUR	Europe	Europe	E	E	B		1	5				E-1551			
1557	≥3	SEAR/WPR, EUR, AMR (global)	SEAR/WPR?	Asia	Asia, Europe, Americas, Global	P	P	A		5	6	P-1557	P-1557	P-1557	P?-1557		P?-1557	
1580	≥4	SEAR/WPR, EUR, AFR, EMR, AMR (global)	SEAR/WPR?	Asia	Asia (NE, SW, minor), Europe, Africa (N, all), Malta	P	P	A		7	7	P-1580	P-1580	P-1580	P-1580	P-1580	P-1580	P-1580
1587	1	EUR	EUR	Europe	Europe	E	E	B		1	4				E-1587			
1593	1	EUR	EUR	Europe	Europe	E	E	B		1	5				E-1593			
1610	1	EUR	EUR	Europe	Europe	E	E	B		1	5		E-1610					
1617	1	AMR	AMR	Americas	Americas (N&S), Caribbean	E	E	B		1	1		E-1617					
1647	2	AMR, EUR	AMR/EUR?	Americas/Europe?	America (N&S, W-Indies), Europe	P(zoo)	P	A	Equine	3	7	P-1647		E-1647	E-1647			
1655	2	AMR, EUR	AMR	America (N)	Americas (N), Europe	P(zoo)	P	A	Equine	5	6	E-1657	E-1658	E-1657	P-1655	E-1658		
1675	1	EUR	EUR	Europe	Europe	E(zoo)	E	A	Equine	4	5	E-1675	E-1675	E-1675	E-1675			
1679	1	EUR	EUR	Europe	Europe	E	E	B		1	4					E-1679		
1688	1	EUR	EUR	Europe	Europe	E(zoo)	E	A	Equine	2	5			E-1688	E-1688			
1693	1	EUR	EUR	Europe	Europe	E(zoo)	E	A	Equine	3	6	E-1693		E-1693	E-1693			
1697	2	AMR, EUR	AMR	Americas	Americas (N&S), Europe	P(zoo)	P	A	Equine	3	3	E-1697		E-1698	E-1698			
1708	1	EUR	EUR	Europe	Europe	E	E	B		3	5		E-1709		E-1708	E-1708		
1712	1	EUR	EUR	Europe	Europe	E	E	B		2	6	E-1712			E-1712			
1718	1	AMR	AMR	Americas	Americas (N&S)	E	E	B		2	2	E-1719			E-1718			
1727	1	EUR	EUR	Europe	Europe	E(zoo)	E	A	Equine	2	3			E-1727	E-1727			
1729	≥3	EUR, SEAR/WPR, AMR	EUR	Russia	Russia, Europe, Americas, Iceland, Asia	P(zoo)	P	A	Equine	6	6	P-1729	P-1729	P-1729	P-1729	E-1729	P-1729	
1732	≥3	EUR, AMR, SEAR/WPR (global)	EUR	Russia	Russia, Caspian Sea, Europe, N. America, Asia, glob	P(zoo)	P	A	Equine	3	4	P-1732	P-1732		P-1732			
1737	2	AMR, EUR (global)	AMR/EUR?	Americas/Europe?	Americas (N, W-Indies), Europe, global	P	P	A		1	5		P?-1737					
1742	1	EUR	EUR	Europe	Europe	E	E	B		2	5		E-1742		P?-1742			
1757	2	AMR, EUR	AMR	Americas (N)	Americas (N, W-Indies), Europe	P	P	A		1	4				P-1757			
1761	2	AMR, EUR (global)	AMR	Americas (N)	Americas (N, W-Indies), Europe, Global	P(zoo)	P	A	Equine	4	6	P-1761	P-1761	P-1761	P?-1761			
1767	2	EUR, AMR	AMR/EUR?	Americas(N)/Europe?	Europe, Nth Am. Siberia	P(zoo)	P	A	Equine	3	6			E-1767	P?-1767	E-1767		
1775	6	EUR, WPR, SEAR, AMR, AFR, EMR	EUR	Europe	Europe (Germany 1st), America, China, Asia, Africa	P(zoo)	P	A	Equine	5	9	P-1775	P?-1775	P?-1775	P?-1775	E-1775		
1780	≥4	WPR, SEAR, EUR, AMR (global)	EUR	Europe	China, Russia, Siberia, SE Asia, India, Europe, Amer	P	P	A		6	6	P-1781	P-1780	P-1780	P-1781	P-1781	P-1781	
1788	2	EUR, AMR	EUR	Russia	Russia, Ukraine, Europe, Americas (N&S, W-Indies)	P	P	A		3	4		P-1788		P?-1788	P-1789		
1799	3	EUR, WPR, AMR	EUR	Russia	Europe, Russia, China, Brazil	P	P	A		2	5				E-1799			P-1800
1805	2	AMR, EUR	AMR	Americas	Americas (N, W-Indies), Europe, Russia	P	P	A		1	5				P-1805			
1815	1	AMR	AMR	Americas	Americas (N&S)	E	E	B		1	3				P?-1815			
1824	1	AMR	AMR	Americas	Americas (N, W-Indies, Mexico)	E	E	B		1	4				E-1824			
1830	≥4	WPR, SEAR, EUR, AMR, Global	WPR	China	China, SE Asia, Russia, Europe, N.America, Philippi	P	P	A		6	5	P-1830	P-1830	P-1830	P-1830	E-1830	P-1830	
1833	≥5	EUR, SEAR, WPR, EMR, AMR	EUR	Russia	Russia, Europe, Asia (W, SE), Egypt, India, America	P	P	A		3	3	P-1833	P-1832		P-1833			
1836	≥6	WPR, SEAR, EUR, EMR, AFR, AMR (global)	WPR	Australia	Australia, SE Asia, Russia, Europe, Africa (S&N), Ru	P	P	A		5	5	P-1836	P-1836		P?-1836	P?-1837		P-1837
1847	≥5	EUR, AMR, AFR, EMR, WPR	EUR	Europe	Europe, Russia (origin?), Nth America, West Indies	P	P	A		4	5	P-1847	P-1847	P-1847	P?-1847			
1857	2	AMR, EUR	AMR	Americas	Americas (N&S, W-Indies), Europe, Russia	P	P	A		2	5				P?-1857			P-1857
1873	3	AMR, EUR, WPR	AMR	Americas (N)	America (N), Europe, Australia	P(zoo)	P	A	Equine	3	6			E-1873	P?-1873			P-1874
1889	≥5	EUR, WPR, SEAR, AMR, AFR	EUR	Uzbekistan	Uzbekistan, Russia, Europe, Asia, America, Africa,	P(zoo)	P	A	Equine	6	3	P-1889	P-1889	P-1889	P-1889	P-1889		P-1889
1899	2	EUR, AMR	AMR/EUR?	Americas/Europe?	Europe, America (N), Alaska, Russia	P(zoo)	P	A	Equine	3	3				P?-1899	P?-1900	P-1899	
1915	1	AMR	AMR	Americas	USA	E(zoo)	E	A	Equine	2	3	E-1915		E-1915				
1918	>4	AMR, WPR, SEAR, EUR (global)	AMR	Americas	America (N), China, Asia, USA, Europe, global	P(zoo)	P	A	Avian genes	7	4	P-1918	P-1918	P-1918	P-1918	P-1918	P-1918	P-1918
1946	≥2	WPR, AMR (global)	WPR	Asia	Asia (Japan, Korea), Australia, USA, global	P	P	A		1	3				P?-1946			
1957	6	WPR, SEAR, EUR, AMR, AFR, EMR (global)	WPR	China	China, Asia, Europe, Eurasia, Near East, South Afric	P(zoo)	P	A	Avian genes	7	7	P-1957	P-1957	P-1957	P-1957	P-1957	P-1957	P-1957
1968	≥4	WPR, SEAR, EUR, AMR, Global	WPR	China	China (HK), SE Asia, Russia, Europe, America (N), G	P(zoo)	P	A	Avian genes	7	4	P-1968	P-1968	P-1968	P-1968	P-1968	P-1968	P-1968
1976	1	AMR	AMR	Americas (N)	USA	E(zoo)	E	A	Swine	4	4	E-1976		E-1976		E-1976		E-1976
1977	≥3	WPR, EUR, AMR (global)	WPR	China	China, Russia, USA, Europe, Siberia, global	P	P	A		4	4		P-1977	P-1977	P?-1977	P-1977		
2009	6	AMR, AFR, SEAR, EUR, EMR, WPR	AMR	Americas	Mexico, Global	P(zoo)	P	A	Swine	2	3	P-2009		P-2009				

Review		Reviewer & expert credentials	Publication year	Period assessed	Outbreaks assessed	Publication references (N)	Outbreak Specific refs. (N)		Number of reviews detailing the 49 outbreaks (N)	Numbers of review-cited publications confirming outbreak relevant info. (N)
#1		David M. Morens*, Jeffery K. Taubenberger: *NIH NIAID Senior Advisor to the Director Office	Published 2011	1510-2009	26	241	63	Total (all outbreaks)	157	229
#2		Svenn-Erik Mamelund: Professor of Demography of Epidemics	Published 2008	1510-1977	42	26	10	mean / outbreak	3.2	4.7
#3		J.K. Taubenberger*, D.M. Morens: *NIH NIAID, Chief of Viral Pathogenesis and Evolution	Published 2009	1510-1977	25	81	11	median / outbreak	3.0	5.0
#4		David M. Morens, Jeffery K. Taubenberger	Published 2010	1510-2009	26	119	30	min. / outbreak	1.0	1.0
#5		Bruno Lina: Professor of Virology & human Pathology	Published 2008	1580-1977	18	35	13	max. / outbreak	7.0	9.0
#6		C.W. Potter: Professor of Molecular and Genetic Medicine	Published 2001	1510-1968	10	41	29			
#7		Eugenia Tognotti: Professor of Medicine and Human Sciences	Published 2009	1580-2009	10	20	19			
			Mean		22.4	80.4	25.0			
			Stdev		11.1	79.1	18.6			

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This influenza outbreak database summary details various categories of influenza pandemics and regional epidemics since 1500CE. Key information was summarized from expert reviews and their pooled review-cited publications (where available online without fee), including the outbreak start dates, expert review confirmation of 'influenza', reviewer assigned (provisional) and final adjudicated outbreak categorization, geographical extent and origination, association with concurrent epizootics/zoonosis, plus other medical-epidemiological information (databased, not provided in S1 Table). See the readme file (Figshare) for a detailed description of the database methodology. Data citation: Outbreak database expert review citations [1]–[7].

Table S2. Logistic regression summary results comparing solar cycle stage groupings of outbreaks.

		Beta coefficients			P-values			Stage probability			Odds ratio			95% CI lower			95% CI upper			
		SSN	GSSN	TSI	SSN	GSSN	TSI	SSN	GSSN	TSI	SSN	GSSN	TSI	SSN	GSSN	TSI	SSN	GSSN	TSI	mean OR
Cat.A&B	P01	1.2	0.8	1.0	(0.01)	(0.08)	(0.03)	0.16	0.13	0.15	3.4	2.2	2.7	1.4	0.9	1.1	8.5	5.5	6.7	2.8
	T01	1.1	1.0	0.9	(0.03)	(0.04)	(0.04)	0.14	0.15	0.14	2.9	2.6	2.6	1.1	1.1	1.0	7.4	6.3	6.4	2.7
	P01+T01	1.1	0.9	1.0	(0.01)	(0.03)	(0.02)	0.15	0.13	0.12	3.1	3.5	3.8	1.4	1.1	1.2	7.2	5.3	5.9	3.5
Cat.A	P01	1.3	1.2	1.1	(0.01)	(0.02)	(0.03)	0.14	0.13	0.13	3.8	3.4	3.0	1.4	1.2	1.1	10.6	9.5	7.9	3.4
	T01	1.1	1.1	1.0	(0.03)	(0.04)	(0.051)	0.12	0.12	0.12	3.2	2.9	2.7	1.1	1.0	1.0	9.0	8.4	7.4	2.9
	P01+T01	1.3	1.2	1.0	(0.01)	(0.01)	(0.02)	0.14	0.13	0.11	2.4	3.2	3.5	1.4	1.3	1.2	8.9	8.1	6.9	3.0
Pan*	P01	1.4	1.3	1.1	(0.01)	(0.02)	(0.03)	0.13	0.12	0.12	4.2	3.8	3.1	1.4	1.3	1.1	12.5	11.2	8.9	3.7
	T01	1.2	1.1	1.0	(0.03)	(0.05)	(0.056)	0.11	0.11	0.11	3.4	3.1	2.8	1.1	1.0	1.0	10.5	9.7	8.3	3.1
	P01+T01	1.3	1.2	1.1	(0.01)	(0.02)	(0.02)	0.15	0.13	0.11	2.7	2.8	3.0	1.4	1.3	1.2	10.4	9.5	7.7	2.8
							Mean	0.14	0.13	0.12	3.2	3.1	3.0	1.3	1.1	1.1	9.4	8.2	7.3	

Regression beta coefficients, P-values, stage probabilities, Odds ratios and 95% lower and upper confidence interval results for solar cycle stage grouping comparisons for SSN, GSSN, and TSI cycles, with outbreak categories comprising pandemics (Cat.A&B, Cat.A, Pandemic +/-concurrent epizootics). Solar cycle stage groupings comprised the peak +/- 1-year (P01), trough +/- 1-year (T01), and P01+T01, versus the combined inter-peak-to-trough plus inter-trough-to-peak stages. These results were derived from S3 Table (R output results). See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[10].

Table S3. Logistic regression results comparing solar cycle stage groupings of outbreaks (R output).

P01 or T01 -v- P_T+T_P	intercept	beta P01	beta T01	p-value intercept	p-value beta P01	p-value beta T01	SE intercept	SE beta P01	SE beta T01	Z intercept	Z beta P01	Z beta T01	R-Sq	AIC	N
Cat. A &B															
SSN_dummy	-2.86	1.22	1.06	0.00	0.01	0.03	0.36	0.5	0.48	-7.9	2.63	2.21	0.31	213.9	319
GSSN_dummy	-2.66	0.80	0.95	0.00	0.08	0.04	0.34	0.5	0.46	-7.7	1.73	2.08	0.31	215.7	312
TSI_dummy	-2.72	1.01	0.94	0.00	0.03	0.04	0.34	0.5	0.46	-7.9	2.21	2.03	0.31	214.9	314
Cat. A															
SSN_dummy	-3.16	1.34	1.15	0.00	0.01	0.03	0.42	0.5	0.54	-7.6	2.59	2.15	0.23	187.3	319
GSSN_dummy	-3.09	1.23	1.08	0.00	0.02	0.04	0.42	0.5	0.54	-7.4	2.37	2.01	0.24	187.3	312
TSI_dummy	-2.99	1.08	1.00	0.00	0.03	0.05	0.39	0.5	0.51	-7.7	2.15	1.95	0.23	188.8	314
Pandemics +/-Epizoo															
SSN_dummy	-3.35	1.43	1.22	0.00	0.01	0.03	0.45	0.6	0.58	-7.4	2.57	2.12	0.19	172.9	319
GSSN_dummy	-3.28	1.32	1.15	0.00	0.02	0.046	0.46	0.6	0.58	-7.2	2.37	1.99	0.20	173.0	312
TSI_dummy	-3.15	1.13	1.04	0.00	0.03	0.06	0.42	0.5	0.55	-7.6	2.12	1.91	0.19	174.6	314

P01+T01 -v- P_T+T_P	intercept	beta P01+T01		p-value intercept	p-value beta P01+T01		SE intercept	SE beta P01+T01		Z intercept	Z beta P01+T01		R-Sq	AIC	N
Cat. A &B															
SSN_dummy	-2.86	1.14		0.00	0.01		0.36	0.4		-7.9	2.71		0.31	212.0	319
GSSN_dummy	-2.66	0.88		0.00	0.03		0.34	0.4		-7.7	2.16		0.31	213.8	312
TSI_dummy	-2.72	0.98		0.00	0.02		0.34	0.4		-7.9	2.41		0.31	212.9	314
Cat. A															
SSN_dummy	-3.16	1.25		0.00	0.01		0.42	0.5		-7.6	2.63		0.23	185.5	319
GSSN_dummy	-3.09	1.16		0.00	0.01		0.42	0.5		-7.4	2.44		0.24	185.4	312
TSI_dummy	-2.99	1.04		0.00	0.02		0.39	0.5		-7.7	2.31		0.23	186.8	314
Pandemics +/-Epizoo															
SSN_dummy	-3.35	1.33		0.00	0.01		0.45	0.5		-7.4	2.59		0.19	171.1	319
GSSN_dummy	-3.28	1.24		0.00	0.02		0.46	0.5		-7.2	2.41		0.20	171.1	312
TSI_dummy	-3.15	1.09		0.00	0.02		0.42	0.5		-7.6	2.26		0.19	172.6	314

Logistic regression coefficients (betas), P-values, Cox Snell pseudo-R-squared, standard errors (SE), Akaike information criterion (AIC) results exported from R (with formatting). This data was used to derive the solar cycle stage grouping probabilities and Odds ratios for influenza outbreaks (categories comprising pandemics), within SSN, GSSN, and TSI 11-year solar cycles. Investigatory stage groupings comprised the peak +/- 1-year (P01), trough +/- 1-year (T01), the combined peak and trough +/- 1-year (P01+T01), versus the combined inter-peak-to-trough plus inter-trough-to-peak stages (P_T+T_P). See the readme file (Figshare) for a detailed description of the methodology. Data sources: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[10].

Table S4. Number, proportion, and percentage of influenza outbreaks by solar cycle stage grouping.

Category A&B, 1700-	P01	T01	P_T+T_P	Total	Pandemics*, 1700-	P01	T01	P_T+T_P	Total
SSN (No Outbreak) (0)	72	73	140	285	SSN (No Outbreak) (0)	75	76	143	294
SSN (with Cat. A&B) (1)	14	12	8	34	SSN (with Pan*+/-Epi) (1)	11	9	5	25
Proportion by stage	16.3	14.1	5.4	10.7	Proportion by stage	12.8	10.6	3.4	7.8
% of outbreaks by stage	41%	35%	24%	100%	% of outbreaks by stage	44%	36%	20%	100%
GSSN (No Outbreak) (0)	77	72	129	278	GSSN (No Outbreak) (0)	78	76	133	287
GSSN (with Cat. A&B) (1)	12	13	9	34	GSSN (with Pan*+/-Epi) (1)	11	9	5	25
Proportion by stage	13.5	15.3	6.5	10.9	Proportion by stage	12.4	10.6	3.6	8.0
% of outbreaks by stage	35%	38%	26%	100%	% of outbreaks by stage	44%	36%	20%	100%
TSI (No Outbreak) (0)	72	71	137	280	TSI (No Outbreak) (0)	75	74	140	289
TSI (with Cat. A&B) (1)	13	12	9	34	TSI (with Pan*+/-Epi) (1)	10	9	6	25
Proportion by stage	15.3	14.5	6.2	10.8	Proportion by stage	11.8	10.8	4.1	8.0
% of outbreaks by stage	38%	35%	26%	100%	% of outbreaks by stage	40%	36%	24%	100%
Category A, 1700-	**P01**	**T01**	**P_T+T_P**	**Total**	**Epidemics*, 1700-**	**P01**	**T01**	**P_T+T_P**	**Total**
SSN (No Outbreak) (0)	74	75	142	291	SSN (No Outbreak) (0)	83	82	145	310
SSN (with Cat. A) (1)	12	10	6	28	SSN (with Epi*+/-Epi) (1)	3	3	3	9
Proportion by stage	14.0	11.8	4.1	8.8	Proportion by stage	3.5	3.5	2.0	2.8
% of outbreaks by stage	43%	36%	21%	100%	% of outbreaks by stage	33%	33%	33%	100%
GSSN (No Outbreak) (0)	77	75	132	284	GSSN (No Outbreak) (0)	88	81	134	303
GSSN (with Cat. A) (1)	12	10	6	28	GSSN (with Epi*+/-Epi) (1)	1	4	4	9
Proportion by stage	13.5	11.8	4.3	9.0	Proportion by stage	1.1	4.7	2.9	2.9
% of outbreaks by stage	43%	36%	21%	100%	% of outbreaks by stage	11%	44%	44%	100%
TSI (No Outbreak) (0)	74	73	139	286	TSI (No Outbreak) (0)	82	80	143	305
TSI (with Cat. A) (1)	11	10	7	28	TSI (with Epi*+/-Epi) (1)	3	3	3	9
Proportion by stage	12.9	12.0	4.8	8.9	Proportion by stage	3.5	3.6	2.1	2.9
% of outbreaks by stage	39%	36%	25%	100%	% of outbreaks by stage	33%	33%	33%	100%

The number, proportion, and percentage of influenza outbreaks by 11-year solar cycle stage grouping for cycles defined by SSN, GSSN, and TSI periods, for different categories of influenza outbreaks (Cat.A&B, Cat.A, pandemics +/-concurrent epizootics or Pan*+/-Epi, and epidemics +/- concurrent epizootics or Epi*+/-Epi). The proportion of outbreaks was calculated as the stage group years with outbreaks divided by the total stage group years*100. Percentage of outbreaks per stage grouping was calculated as number of years in a stage with outbreaks divided by the total outbreak years across all stage groupings. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[10].

Table S5. Solar cycle stage grouping comparisons between pandemics and epidemics.

	SSN		GSSN		TSI		CRI		MeV	
Solar cycle stage	Odds Ratio	p-value	Odds Ratio	p-value	Odds Ratio	p-value	Odds Ratio	p-value	Odds Ratio	p-value
Pandemics* versus Epidemics* (*= +/-concurrent epizootics/zoonosis)										
P01 vs T_P+P_T	2.1	(0.62)	7.9	(0.12)	1.6	(0.66)	1.3	(>0.999)	Inf	(0.25)
T01 vs T_P+P_T	1.7	(0.64)	1.8	(0.66)	1.5	(>0.999)	Inf	(0.26)	0.6	(0.68)
P01+T01 vs T_P+P_T	2.0	(0.65)	3.1	(0.20)	1.6	(0.67)	2.3	(0.42)	1.1	(>0.999)
P+T vs All-(P+T)	0.8	(>0.999)	0.7	(0.64)	0.6	(0.67)	0.6	(0.62)	0.4	(0.36)

Fishers exact test results (Odds ratios and P-values) for an array of solar cycle stage-grouping comparisons between pandemics* and epidemics*. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[12].

Table S6: Simple logistic regression model results (2-11yr SMA, non-timing risk factors).

Cat.A&B, GT°C, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC	Epidemics*, NHT°C, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.6	0.04	0.28	-2.09	-0.35	0.17	0.03	314.3	2yr	-2.9	0.01	1.12	-2.56	-0.70	0.27	0.02	152.0
3yr	-0.6	0.04	0.28	-2.11	-0.36	0.17	0.03	314.2	3yr	-2.9	0.01	1.13	-2.58	-0.70	0.27	0.02	151.8
4yr	-0.6	0.03	0.28	-2.13	-0.36	0.17	0.03	314.1	4yr	-2.9	0.01	1.13	-2.60	-0.71	0.27	0.02	151.7
5yr	-0.6	0.03	0.28	-2.14	-0.36	0.17	0.03	314.0	5yr	-3.0	0.01	1.14	-2.61	-0.71	0.27	0.02	151.7
6yr	-0.6	0.03	0.28	-2.15	-0.37	0.17	0.03	314.0	6yr	-3.0	0.01	1.14	-2.62	-0.72	0.27	0.02	151.6
7yr	-0.6	0.03	0.28	-2.12	-0.36	0.17	0.03	314.1	7yr	-3.0	0.01	1.15	-2.63	-0.72	0.27	0.02	151.6
8yr	-0.6	0.04	0.28	-2.10	-0.36	0.17	0.03	314.2	8yr	-3.0	0.01	1.15	-2.63	-0.72	0.27	0.02	151.6
9yr	-0.6	0.04	0.28	-2.09	-0.35	0.17	0.03	314.3	9yr	-3.0	0.01	1.16	-2.62	-0.72	0.27	0.02	151.6
10yr	-0.6	0.04	0.28	-2.08	-0.35	0.17	0.03	314.3	10yr	-3.1	0.01	1.16	-2.62	-0.72	0.28	0.02	151.6
11yr	-0.6	0.04	0.28	-2.07	-0.35	0.17	0.03	314.4	11yr	-3.1	0.01	1.17	-2.62	-0.72	0.28	0.02	151.6
Epidemics*, NHT°C, 1700	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC	Cat.A&B, SIC, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-3.4	0.01	1.33	-2.56	-0.88	0.34	0.03	78.3	2yr	-0.8	0.052	0.40	-1.95	-0.37	0.19	0.02	215.0
3yr	-3.4	0.01	1.33	-2.58	-0.89	0.34	0.03	78.2	3yr	-0.8	0.07	0.43	-1.83	-0.35	0.19	0.02	215.4
4yr	-3.4	0.01	1.33	-2.58	-0.89	0.35	0.03	78.1	4yr	-1.0	0.04	0.46	-2.08	-0.41	0.20	0.02	214.3
5yr	-3.5	0.01	1.34	-2.59	-0.89	0.35	0.03	78.1	5yr	-1.0	0.03	0.48	-2.15	-0.43	0.20	0.02	213.9
6yr	-3.5	0.01	1.34	-2.59	-0.90	0.35	0.03	78.1	6yr	-1.1	0.03	0.50	-2.21	-0.44	0.20	0.02	213.6
7yr	-3.5	0.01	1.34	-2.59	-0.90	0.35	0.03	78.0	7yr	-1.0	0.047	0.50	-1.99	-0.39	0.20	0.02	214.7
8yr	-3.5	0.01	1.35	-2.59	-0.90	0.35	0.03	78.0	8yr	-1.0	0.054	0.51	-1.93	-0.38	0.20	0.02	214.9
9yr	-3.5	0.01	1.35	-2.59	-0.90	0.35	0.03	78.0	9yr	-0.9	0.07	0.51	-1.84	-0.36	0.20	0.02	215.3
10yr	-3.5	0.01	1.36	-2.60	-0.91	0.35	0.03	77.9	10yr	-0.8	0.11	0.51	-1.60	-0.31	0.20	0.01	216.2
11yr	-3.6	0.01	1.36	-2.61	-0.91	0.35	0.03	77.8	11yr	-0.8	0.15	0.52	-1.45	-0.28	0.19	0.01	216.7
Epidemics*, IAR, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC	Cat.A, SIC, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	14.9	0.09	8.90	1.67	0.45	0.27	0.01	153.6	2yr	-0.8	0.07	0.43	-1.79	-0.37	0.21	0.02	189.1
3yr	17.4	0.13	11.45	1.52	0.43	0.28	0.03	146.7	3yr	-0.7	0.12	0.47	-1.57	-0.33	0.21	0.01	189.9
4yr	17.1	0.20	13.27	1.29	0.35	0.27	0.03	146.6	4yr	-0.8	0.09	0.50	-1.69	-0.36	0.21	0.01	189.4
5yr	29.2	0.07	16.13	1.81	0.52	0.29	0.04	143.9	5yr	-0.8	0.11	0.51	-1.60	-0.34	0.21	0.01	189.7
6yr	41.3	0.02	18.30	2.26	0.65	0.29	0.04	141.1	6yr	-0.9	0.09	0.53	-1.67	-0.36	0.21	0.01	189.5
7yr	25.2	0.18	18.90	1.33	0.36	0.27	0.05	137.9	7yr	-0.8	0.15	0.53	-1.45	-0.31	0.21	0.01	190.2
8yr	23.4	0.24	19.78	1.18	0.31	0.27	0.05	137.8	8yr	-0.7	0.17	0.54	-1.37	-0.29	0.21	0.01	190.4
9yr	31.3	0.14	21.02	1.49	0.40	0.27	0.06	136.5	9yr	-0.7	0.20	0.55	-1.29	-0.27	0.21	0.01	190.7
10yr	37.1	0.09	22.19	1.67	0.45	0.27	0.06	135.5	10yr	-0.6	0.28	0.55	-1.08	-0.22	0.21	0.01	191.2
11yr	39.2	0.09	23.15	1.69	0.45	0.26	0.06	135.0	11yr	-0.5	0.34	0.55	-0.95	-0.20	0.21	0.01	191.5
Cat.A&B, CRI, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC	Epidemics*, CRI, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	1.4	0.08	0.81	1.77	0.34	0.19	0.03	210.3	2yr	6.5	0.0009	1.96	3.31	1.54	0.47	0.05	70.8
3yr	1.8	0.04	0.84	2.10	0.41	0.19	0.04	208.7	3yr	6.6	0.0007	1.95	3.37	1.51	0.45	0.05	70.4
4yr	2.0	0.02	0.86	2.34	0.45	0.19	0.04	207.4	4yr	6.6	0.0006	1.93	3.44	1.47	0.43	0.05	70.1
5yr	2.2	0.01	0.89	2.52	0.47	0.19	0.05	206.3	5yr	6.7	0.0005	1.91	3.50	1.42	0.41	0.05	69.8
6yr	2.3	0.01	0.91	2.58	0.48	0.18	0.05	205.9	6yr	6.7	0.0004	1.89	3.53	1.35	0.38	0.05	69.9
7yr	2.3	0.01	0.92	2.53	0.46	0.18	0.05	206.0	7yr	6.5	0.0004	1.85	3.53	1.28	0.36	0.05	70.4
8yr	2.3	0.02	0.94	2.40	0.43	0.18	0.05	206.5	8yr	6.5	0.0004	1.84	3.55	1.23	0.35	0.05	70.4
9yr	2.2	0.02	0.96	2.29	0.40	0.18	0.05	206.8	9yr	6.6	0.0003	1.85	3.59	1.22	0.34	0.05	70.1
10yr	1.8	0.07	0.99	1.82	0.32	0.18	0.05	204.3	10yr	5.9	0.0017	1.88	3.14	1.06	0.34	0.06	67.2
11yr	1.9	0.06	1.00	1.87	0.33	0.18	0.06	203.8	11yr	6.2	0.0013	1.91	3.21	1.10	0.34	0.06	66.6
Epidemics*, TSI, 1610-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC	Epidemics*, TSI, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-1.4	0.03	0.67	-2.11	-0.66	0.31	0.09	120.9	2yr	-2.1	0.07	1.16	-1.82	-0.78	0.43	0.01	82.1
3yr	-1.4	0.04	0.67	-2.06	-0.63	0.30	0.09	121.2	3yr	-2.3	0.06	1.20	-1.91	-0.82	0.43	0.01	81.7
4yr	-1.4	0.04	0.67	-2.06	-0.61	0.30	0.09	121.2	4yr	-2.5	0.046	1.24	-1.99	-0.84	0.42	0.02	81.3
5yr	-1.4	0.04	0.67	-2.09	-0.61	0.29	0.09	121.0	5yr	-2.7	0.04	1.29	-2.09	-0.86	0.41	0.02	80.9
6yr	-1.5	0.03	0.68	-2.16	-0.61	0.28	0.09	120.7	6yr	-2.9	0.03	1.34	-2.19	-0.88	0.40	0.02	80.4
7yr	-1.5	0.03	0.68	-2.22	-0.62	0.28	0.10	120.4	7yr	-3.2	0.02	1.39	-2.28	-0.89	0.39	0.02	80.1
8yr	-1.6	0.02	0.68	-2.28	-0.62	0.27	0.10	120.1	8yr	-3.4	0.02	1.43	-2.34	-0.89	0.38	0.02	79.8
9yr	-1.6	0.03	0.71	-2.20	-0.61	0.28	0.11	113.7	9yr	-3.5	0.02	1.47	-2.41	-0.91	0.38	0.02	79.4
10yr	-1.6	0.03	0.71	-2.24	-0.62	0.28	0.11	113.5	10yr	-3.8	0.01	1.51	-2.49	-0.93	0.37	0.02	79.0
11yr	-1.6	0.02	0.71	-2.28	-0.63	0.28	0.11	113.2	11yr	-3.9	0.01	1.53	-2.53	-0.95	0.37	0.02	78.7

Pandemics*, TSI, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	0.7	0.10	0.42	1.62	0.32	0.20	0.08	205.4
3yr	0.6	0.19	0.43	1.32	0.26	0.20	0.08	206.2
4yr	0.5	0.29	0.45	1.06	0.21	0.20	0.08	206.6
5yr	0.4	0.36	0.46	0.92	0.18	0.20	0.08	206.8
6yr	0.4	0.38	0.48	0.88	0.18	0.20	0.08	206.7
7yr	0.4	0.37	0.49	0.89	0.18	0.20	0.08	206.5
8yr	0.5	0.29	0.51	1.06	0.22	0.21	0.08	206.0
9yr	0.7	0.20	0.53	1.28	0.27	0.21	0.08	205.3
10yr	0.8	0.14	0.55	1.47	0.32	0.22	0.08	204.6
11yr	0.9	0.12	0.56	1.57	0.34	0.22	0.08	204.1

Epidemics*, SSN, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.01	0.16	0.01	-1.41	-0.64	0.45	0.01	83.5
3yr	-0.01	0.10	0.01	-1.62	-0.77	0.48	0.01	82.4
4yr	-0.02	0.07	0.01	-1.78	-0.86	0.48	0.01	81.6
5yr	-0.02	0.047	0.01	-1.99	-0.96	0.49	0.02	80.5
6yr	-0.03	0.02	0.01	-2.27	-1.09	0.48	0.02	78.9
7yr	-0.03	0.01	0.01	-2.45	-1.11	0.45	0.03	78.0
8yr	-0.04	0.01	0.01	-2.62	-1.11	0.43	0.03	77.1
9yr	-0.04	0.01	0.01	-2.76	-1.13	0.41	0.03	76.2
10yr	-0.04	0.01	0.02	-2.53	-1.05	0.42	0.05	70.7
11yr	-0.04	0.01	0.02	-2.58	-1.10	0.43	0.05	70.2

Epidemics*, GSSN, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.2	0.06	0.13	-1.90	-0.72	0.38	0.09	121.1
3yr	-0.2	0.08	0.13	-1.77	-0.63	0.36	0.09	121.8
4yr	-0.2	0.08	0.13	-1.78	-0.62	0.35	0.09	121.8
5yr	-0.3	0.049	0.14	-1.97	-0.69	0.35	0.09	120.8
6yr	-0.3	0.03	0.15	-2.11	-0.71	0.34	0.10	120.1
7yr	-0.3	0.04	0.15	-2.11	-0.66	0.32	0.10	120.3
8yr	-0.3	0.03	0.15	-2.16	-0.65	0.30	0.10	120.2
9yr	-0.4	0.01	0.17	-2.60	-0.81	0.31	0.12	110.9
10yr	-0.5	0.01	0.17	-2.69	-0.83	0.31	0.12	110.4
11yr	-0.5	0.01	0.17	-2.80	-0.86	0.31	0.12	109.6

Epidemics*, GSSN, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.3	0.09	0.16	-1.68	-0.78	0.47	0.01	82.2
3yr	-0.3	0.09	0.17	-1.68	-0.77	0.46	0.01	82.3
4yr	-0.3	0.09	0.18	-1.72	-0.77	0.45	0.01	82.2
5yr	-0.4	0.04	0.21	-2.03	-0.96	0.47	0.02	80.5
6yr	-0.5	0.02	0.23	-2.33	-1.10	0.47	0.02	78.8
7yr	-0.5	0.02	0.24	-2.32	-0.99	0.43	0.02	79.3
8yr	-0.6	0.02	0.24	-2.37	-0.94	0.40	0.02	79.3
9yr	-0.6	0.01	0.25	-2.46	-0.92	0.37	0.02	79.0
10yr	-0.7	0.01	0.26	-2.60	-0.95	0.37	0.02	78.2
11yr	-0.7	0.01	0.27	-2.69	-0.99	0.37	0.03	77.7

Epidemics*, 10Be, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	0.9	0.07	0.49	1.78	0.36	0.20	0.01	153.8
3yr	1.1	0.04	0.52	2.03	0.41	0.20	0.03	145.6
4yr	0.8	0.16	0.58	1.39	0.30	0.21	0.03	146.6
5yr	0.9	0.14	0.60	1.46	0.31	0.21	0.03	145.6
6yr	0.9	0.13	0.61	1.53	0.32	0.21	0.04	144.7
7yr	1.0	0.14	0.65	1.49	0.32	0.22	0.05	137.8
8yr	0.9	0.19	0.67	1.30	0.29	0.22	0.05	137.7
9yr	1.0	0.15	0.68	1.43	0.31	0.22	0.06	136.9
10yr	1.0	0.14	0.70	1.47	0.32	0.22	0.06	136.4
11yr	1.1	0.11	0.71	1.59	0.35	0.22	0.06	135.6

Epidemics*, 10Be, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	1.1	0.08	0.64	1.77	0.48	0.27	0.02	80.8
3yr	1.6	0.03	0.73	2.15	0.62	0.29	0.05	72.1
4yr	1.4	0.08	0.80	1.75	0.52	0.30	0.05	73.0
5yr	1.6	0.06	0.84	1.86	0.55	0.30	0.05	72.3
6yr	1.7	0.051	0.86	1.95	0.58	0.30	0.06	71.5
7yr	1.7	0.06	0.93	1.87	0.59	0.31	0.08	64.6
8yr	1.6	0.10	0.97	1.64	0.52	0.32	0.08	65.0
9yr	1.7	0.09	0.99	1.70	0.54	0.32	0.09	64.6
10yr	1.8	0.09	1.03	1.72	0.55	0.32	0.09	64.3
11yr	1.9	0.07	1.06	1.80	0.59	0.33	0.09	63.7

Pandemics*, MeV, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	0.001	0.04	0.00	2.01	0.34	0.17	0.02	227.4
3yr	0.001	0.07	0.00	1.84	0.31	0.17	0.02	228.0
4yr	0.001	0.08	0.00	1.76	0.30	0.17	0.02	228.3
5yr	0.001	0.09	0.00	1.70	0.30	0.17	0.02	228.5
6yr	0.001	0.10	0.00	1.65	0.29	0.18	0.02	228.6
7yr	0.001	0.11	0.00	1.60	0.28	0.18	0.02	228.8
8yr	0.001	0.11	0.00	1.59	0.28	0.18	0.02	228.8
9yr	0.001	0.11	0.00	1.61	0.29	0.18	0.02	228.7
10yr	0.001	0.11	0.00	1.61	0.29	0.18	0.02	228.7
11yr	0.001	0.11	0.00	1.61	0.29	0.18	0.02	228.7

Epidemics*, MeV, 1500-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.002	0.06	0.00	-1.87	-0.56	0.30	0.01	155.1
3yr	-0.002	0.06	0.00	-1.87	-0.56	0.30	0.01	155.1
4yr	-0.002	0.06	0.00	-1.86	-0.54	0.29	0.01	155.2
5yr	-0.003	0.06	0.00	-1.87	-0.54	0.29	0.01	155.2
6yr	-0.003	0.06	0.00	-1.90	-0.54	0.29	0.01	155.1
7yr	-0.003	0.06	0.00	-1.92	-0.54	0.28	0.01	155.1
8yr	-0.003	0.054	0.00	-1.93	-0.54	0.28	0.01	155.0
9yr	-0.003	0.051	0.00	-1.95	-0.54	0.28	0.01	155.0
10yr	-0.003	0.049	0.00	-1.97	-0.54	0.28	0.01	154.9
11yr	-0.003	0.049	0.00	-1.97	-0.54	0.27	0.01	154.9

Epidemics*, MeV, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.01	0.02	0.00	-2.34	-1.25	0.53	0.03	77.5
3yr	-0.01	0.02	0.00	-2.37	-1.23	0.52	0.03	77.5
4yr	-0.01	0.02	0.00	-2.37	-1.19	0.50	0.03	77.7
5yr	-0.01	0.02	0.00	-2.41	-1.16	0.48	0.03	77.7
6yr	-0.01	0.01	0.00	-2.48	-1.15	0.47	0.03	77.4
7yr	-0.01	0.01	0.00	-2.54	-1.14	0.45	0.03	77.3
8yr	-0.01	0.01	0.00	-2.61	-1.14	0.44	0.03	77.0
9yr	-0.01	0.01	0.00	-2.70	-1.16	0.43	0.03	76.5
10yr	-0.01	0.01	0.00	-2.78	-1.19	0.43	0.03	76.0
11yr	-0.01	0.005	0.00	-2.82	-1.19	0.42	0.03	75.8

Pandemics*, SIC, 1700-	Coeffs. (non std.)	p-values	SE (non std.)	Z-stats	Coeffs. (std.)	SE (std.)	Cox Snell R-squared	AIC
2yr	-0.7	0.12	0.45	-1.57	-0.34	0.22	0.01	175.6
3yr	-0.6	0.21	0.49	-1.27	-0.27	0.22	0.01	176.5
4yr	-0.7	0.17	0.52	-1.38	-0.30	0.22	0.01	176.2
5yr	-0.7	0.20	0.53	-1.29	-0.28	0.22	0.01	176.4
6yr	-0.8	0.15	0.55	-1.44	-0.32	0.22	0.01	176.0
7yr	-0.7	0.22	0.56	-1.22	-0.27	0.22	0.01	176.6
8yr	-0.7	0.24	0.57	-1.19	-0.26	0.22	0.01	176.7
9yr	-0.7	0.24	0.57	-1.18	-0.26	0.22	0.01	176.7
10yr	-0.6	0.33	0.57	-0.98	-0.21	0.22	0.01	177.2
11yr	-0.5	0.38	0.58	-0.88	-0.19	0.22	0.01	177.3

Coefficients of simple logistic regression, P-values, standard errors (SE), Z-statistics, Cox Snell pseudo-R-squared, and Akaike information criteria (AIC) results downloaded from R. A simple bivariate logistic regression was used to investigate the impact of a single independent variable (2-11 year SMA) in explaining the variability of the

dependent variable (outbreak category) between 1500 or 1700, and 2018, in case the outcome was binary. See the readme file (Figshare) for a detailed methodology description. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S7. Solar cycle and influenza outbreak per cycle metrics.

Solar cycle & Outbreak metrics	SSN	GSSN	TSI	CRI	MeV
Start year (1st post-1700 trough)	1711	1711	1712	1721	1709
End year (last post-1700 trough)	2008	2008	2008	2000	1997
No.# of Trough to Trough cycles	27	27	27	26	24
No.# of Category A & B outbreaks	32	32	32	30	32
No.# Category A outbreaks	27	27	27	27	27
No.# Pandemic* outbreaks	24	24	24	24	24
No.# Epidemic* outbreaks	8	8	8	6	8
Category A&B outbreaks per year (mean of means)	0.11	0.11	0.11	0.11	0.09
standard error of means	0.02	0.02	0.02	0.01	0.02
Category A outbreaks per year (mean of means)	0.09	0.09	0.09	0.10	0.11
standard error of means	0.02	0.02	0.02	0.01	0.02
Pandemics* per year (mean of means)	0.08	0.08	0.08	0.09	0.08
standard error of means	0.01	0.01	0.01	0.01	0.01
Epidemics* per year (mean of means)	0.03	0.03	0.03	0.02	0.03
standard error of means	0.01	0.01	0.01	0.01	0.01
Mean solar cycle period (years)	11.0	11.0	11.0	10.7	12.0
Solar cycle period standard deviation	1.2	1.3	1.3	1.9	3.9
Category A&B mean interval (yrs)	9.0	9.0	9.1	9.2	10.6
Category A mean interval (yrs)	10.6	10.5	10.8	10.0	8.9
Pandemics* mean interval (yrs)	12.0	11.9	12.3	11.2	12.1

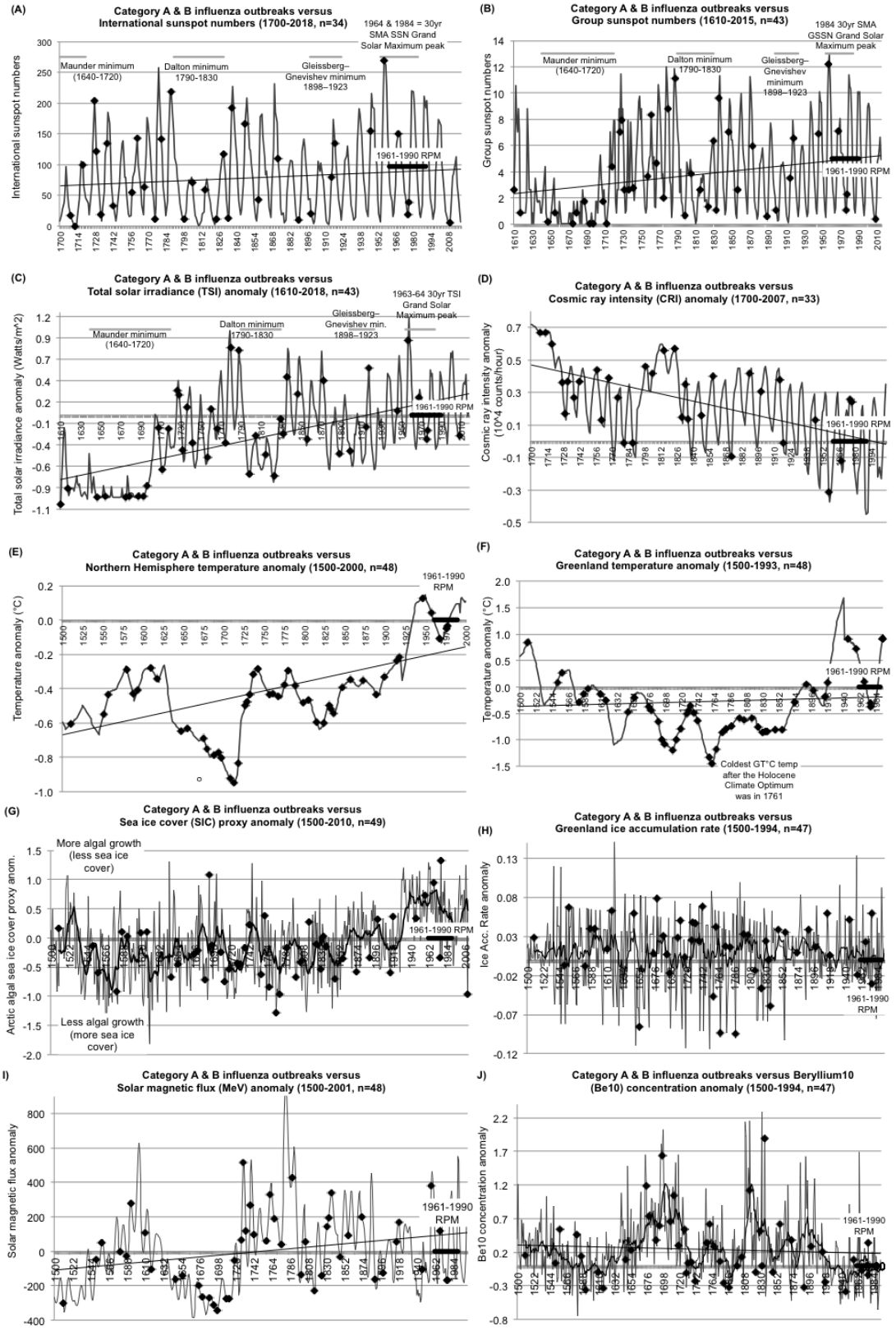
The assessment period, number of cycles, the cycle mean duration and standard deviation for SSN, GSSN, TSI, CRI, and MeV trough-to-trough cycles are detailed. The mean of mean number of influenza outbreaks per year and standard error (SE), and the mean interval by outbreak category comprising pandemics are also detailed. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Solar cycle data citations [8]–[12].

Table S8: Simple linear regression results (cycle mean variable anomaly, cycle mean outbreaks/year).

NS; non-standardized, S; standardized			NS	NS	NS	S	S	NS/S	NS/S	NS/S	NS/S	NS/S	NS/S
Outbreak category	Cycle periods defined by:	T_T Cycle avg.	Coeff.	Pr(>|t|)	SE coeff.	Coeff.	SE coeff.	t-value	R-sqd.	F-stat	F-stat Pr(>|t|)	F-stat DF1	F-stat DF2
Cat. A&B	SSN	GT°C avg.	-0.05	0.03	0.02	-0.43	0.18	-2.36	0.19	5.56	0.03	1	24
Cat. A&B	SSN	SIC avg.	-0.11	0.01	0.04	-0.49	0.17	-2.78	0.24	7.74	0.01	1	25
Cat. A&B	TSI	NHT°C avg.	-0.15	0.03	0.06	-0.42	0.18	-2.35	0.19	5.52	0.03	1	24
Cat. A&B	TSI	GT°C avg.	-0.06	0.01	0.02	-0.49	0.17	-2.79	0.25	7.79	0.01	1	24
Cat. A&B	TSI	SIC avg.	-0.10	0.01	0.03	-0.50	0.17	-2.92	0.25	8.53	0.01	1	25
Cat. A&B	GSSN	GT°C avg.	-0.05	0.03	0.02	-0.43	0.18	-2.37	0.19	5.62	0.03	1	24
Cat. A&B	GSSN	SIC avg.	-0.11	0.01	0.04	-0.49	0.17	-2.83	0.24	8.03	0.01	1	25
Cat. A&B	CRI	CRI avg.	0.23	0.03	0.10	0.43	0.18	2.36	0.19	5.58	0.03	1	24
Cat. A&B	CRI	NHT°C avg.	-0.16	0.02	0.06	-0.46	0.18	-2.54	0.21	6.46	0.02	1	24
Cat. A&B	CRI	GT°C avg.	-0.05	0.02	0.02	-0.44	0.18	-2.44	0.21	5.97	0.02	1	23
Cat. A&B	CRI	SIC avg.	-0.09	0.01	0.03	-0.47	0.18	-2.63	0.22	6.90	0.01	1	24
Cat. A	CRI	SIC avg.	-0.08	0.03	0.04	-0.43	0.18	-2.35	0.19	5.52	0.03	1	24
Pan*	TSI	GT°C avg.	-0.04	0.04	0.02	-0.41	0.18	-2.21	0.17	4.88	0.04	1	24
Pan*	CRI	SIC avg.	-0.07	0.04	0.03	-0.41	0.19	-2.22	0.17	4.93	0.04	1	24
Pan*	MeV	MeV avg.	0.00	0.01	0.00	0.51	0.18	2.78	0.26	7.71	0.01	1	22
Pan*	MeV	IAR avg.	2.63	0.04	1.22	0.42	0.19	2.15	0.17	4.61	0.04	1	22
Epi*	SSN	Be10 avg.	0.07	0.03	0.03	0.45	0.19	2.36	0.19	5.56	0.03	1	23
Epi*	TSI	TSI avg.	-0.09	0.05	0.04	-0.39	0.18	-2.11	0.15	4.44	0.045	1	25
Epi*	TSI	Be10 avg.	0.09	0.02	0.03	0.47	0.19	2.47	0.21	6.10	0.02	1	23
Epi*	TSI	NHT°C avg.	-0.10	0.03	0.04	-0.44	0.19	-2.37	0.19	5.60	0.03	1	24
Epi*	TSI	IAR avg.	-1.97	0.04	0.92	-0.42	0.20	-2.14	0.17	4.60	0.04	1	23
Epi*	GSSN	Be10 avg.	0.07	0.03	0.03	0.44	0.19	2.27	0.18	5.16	0.03	1	23
Epi*	CRI	CRI avg.	0.13	0.01	0.05	0.49	0.18	2.74	0.24	7.50	0.01	1	24

Non-standardized and standardized linear regression coefficients, Pr(>|t|)<0.05, standard errors (SE), T-values, Cox Snell pseudo-R-squared values, F-statistic values, and F-stat degrees of freedom (DF) results output from R. Simple linear regression was used to investigate if the mean number of outbreaks per solar cycle year (dependent variable) could be predicted by the cycle mean independent variable, for cycles defined by SSN, GSSN, TSI, CRI, and MeV trough to trough periods. The asterix above pandemic* and epidemic* means +/-concurrent epizootics/zoonoses. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Figure S9. Linear plots of independent variables with Cat.A&B influenza outbreaks.


(A)
Category A & B influenza outbreaks versus
International sunspot numbers (1700-2018, n=34)
1964 & 1984 = 30yr SMA SSN Grand Solar Maximum peak
Maunder minimum (1640-1720)
Dalton minimum 1790-1830
Gleissberg–Gnevishev minimum 1898–1923
1961-1990 RPM
International sunspot numbers
(B)
Category A & B influenza outbreaks versus
Group sunspot numbers (1610-2015, n=43)
1984 30yr SMA GSSN Grand Solar Maximum peak
Maunder minimum (1640-1720)
Dalton minimum 1790-1830
Gleissberg–Gnevishev minimum 1898–1923
1961-1990 RPM
Group sunspot numbers
(C)
Category A & B influenza outbreaks versus
Total solar irradiance (TSI) anomaly (1610-2018, n=43)
1963-64 30yr TSI Grand Solar Maximum peak
Maunder minimum (1640-1720)
Dalton minimum 1790-1830
Gleissberg–Gnevishev min. 1898–1923
1961-1990 RPM
Total solar irradiance anomaly (Watts/m^2)
(D)
Category A & B influenza outbreaks versus
Cosmic ray intensity (CRI) anomaly (1700-2007, n=33)
1961-1990 RPM
Cosmic ray intensity anomaly (10^4 counts/hour)
(E)
Category A & B influenza outbreaks versus
Northern Hemisphere temperature anomaly (1500-2000, n=48)
1961-1990 RPM
Temperature anomaly (°C)
(F)
Category A & B influenza outbreaks versus
Greenland temperature anomaly (1500-1993, n=48)
1961-1990 RPM
Coldest GT°C temp after the Holocene Climate Optimum was in 1761
Temperature anomaly (°C)
(G)
Category A & B influenza outbreaks versus
Sea ice cover (SIC) proxy anomaly (1500-2010, n=49)
More algal growth (less sea ice cover)
Less algal growth (more sea ice cover)
1961-1990 RPM
Arctic algal sea ice cover proxy anom.
(H)
Category A & B influenza outbreaks versus
Greenland ice accumulation rate (1500-1994, n=47)
1961-1990 RPM
Ice Acc. Rate anomaly
(I)
Category A & B influenza outbreaks versus
Solar magnetic flux (MeV) anomaly (1500-2001, n=48)
1961-1990 RPM
Solar magnetic flux anomaly
(J)
Category A & B influenza outbreaks versus Beryllium10
(Be10) concentration anomaly (1500-1994, n=47)
1961-1990 RPM
Be10 concentration anomaly

Cat.A&B outbreaks were plotted relative to: **(A)** sunspot number (SSN), **(B)** group sunspot number (GSSN), **(C)** total solar irradiance (TSI), **(D)** cosmic ray intensity (CRI), **(E)** Northern Hemisphere temperature (NHT), **(F)** Greenland temperature, **(G)** sea ice cover (SIC), **(H)** Greenland ice accumulation rate, **(I)** solar modulation function (MeV), **(J)** Beryllium10 concentration (^{10}Be) anomalies (except SSN and GSSN, which use the raw data). Generally accepted grand solar minimum and maximum periods (A-C), and the 1961-1990 RPM (A-J) are graphically annotated. See the readme file (Figshare) for a detailed description of the methodology used to calculate anomalies and create the graphics. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S10. Outbreak proportion and variable anomaly quartile grouping comparisons.

Outbreak category	A&B	A&B	Epi*	Epi*	A&B	A&B	A	A	Pan*	A	Epi*
Data/analysis start year	1500	1700	1500	1700	1500	1700	1500	1700	1700	1700	1500
Anomaly categories	GT°C	GT°C	GT°C	NHT°C	SIC	SIC	SIC	SIC	SIC	IAR	IAR
Negative vs Positive						6.4	4.0	5.6			
						(0.01)	(0.046)	(0.02)			
Large -ve vs All +ve				na							
				(0.048)							
Large+medium -ve vs All +ve						8.5	5.3	7.7	4.6		
						(0.00)	(0.02)	(0.01)	(0.03)		
Large+medium -ve vs Large+medium +ve	5.2	4.0	na			6.0		5.8			
	(0.02)	(0.046)	(0.03)			(0.01)		(0.02)			
Medium -ve vs Medium +ve	4.4				3.8		4.4				
	(0.04)				(0.050)		(0.04)				
Large +ve vs All -ve											4.91
											(0.02)
Large+medium +ve vs All -ve	4.0		na			4.3		4.0		3.8	
	(0.045)		(0.03)			(0.04)		(0.046)		(0.050)	
Outbreak category	Epi*	Epi*	Epi*	A	Pan*	A	Pan*	Pan*	Epi*	Epi*	
Data/analysis start year	1500	1700	1500	1500	1500	1700	1700	1500	1500	1700	
Anomaly categories	CRI	CRI	TSI	SSN	SSN	SSN	SSN	MeV	GSSN	MeV	
Negative vs Positive									6.48		
									(0.045)		
Large -ve vs All +ve			10.36							11.1	
			(0.01)							(0.03)	
Large+medium -ve vs All +ve									7.45		
									(0.04)		
Large+medium -ve vs Large+medium +ve										8.0	
										(0.04)	
Medium -ve vs Medium +ve					4.5					15.7	
					(0.04)					(0.04)	
Large +ve vs All -ve	na	na						2.89			
	(0.03)	(0.03)						(0.048)			
Large+medium +ve vs All -ve				5.4	5.7	5.4	5.7	4.60			
				(0.02)	(0.02)	(0.02)	(0.02)	(0.03)			

Statistically significant Chi-square statistic (degrees of freedom, df=1 in all cases) or Fishers exact test Odds Ratio results (underscored, df=not applicable), with P-values placed below them (in brackets)(na=not applicable). These results are presented for an array of significant outbreak proportion and variable anomaly quartile grouping comparisons, which differed by sign and magnitude. This data was derived in R from S11 Table data. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S11. Numbers of outbreak and non-outbreak years by +/- variable quartiles.

(A) Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Cat.A&B, 1500-													
Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	8	9	2	4	9	2	SSN	44	94	50	24	47	26
GSSN	8	17	5	3	9	1	GSSN	58	128	65	28	54	30
TSI	9	15	6	4	6	3	TSI	64	130	67	26	52	27
CRI	1	2	3	7	14	6	CRI	12	31	11	51	117	53
MeV	7	12	5	6	12	6	MeV	62	127	64	50	101	50
Be10	5	8	2	8	17	7	Be10	33	68	36	74	148	75
NHT°C	11	23	12	1	0	1	NHT°C	102	203	101	11	25	11
GT°C	11	23	6	2	2	4	GT°C	76	166	84	30	62	28
SIC	6	21	6	4	7	5	SIC	66	128	66	50	102	50
IAR	5	5	2	11	18	6	IAR	39	83	42	65	136	69
Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Cat.A, 1500-													
Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	5	7	2	4	9	1	SSN	47	96	50	24	47	27
GSSN	7	10	4	3	9	1	GSSN	59	135	66	28	54	30
TSI	6	11	4	4	6	3	TSI	67	134	69	26	52	27
CRI	1	2	3	2	13	6	CRI	12	31	11	56	118	53
MeV	4	9	2	6	9	6	MeV	65	130	67	50	104	50
Be10	3	5	2	4	15	6	Be10	35	71	36	78	150	76
NHT°C	7	18	9	1	0	1	NHT°C	106	208	104	11	25	11
GT°C	9	17	3	2	2	3	GT°C	78	172	87	30	62	29
SIC	5	18	4	4	5	1	SIC	67	131	68	50	104	54
IAR	5	3	1	7	15	4	IAR	39	85	43	69	139	71
Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Pandemics +/-epizootics, 1500-													
Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	5	6	1	3	9	1	SSN	47	97	51	25	47	27
GSSN	5	8	3	3	8	1	GSSN	61	137	67	28	55	30
TSI	3	10	3	4	5	3	TSI	70	135	70	26	53	27
CRI	1	2	3	2	10	6	CRI	12	31	11	56	121	53
MeV	2	7	2	6	9	4	MeV	67	132	67	50	104	52
Be10	3	4	2	3	11	6	Be10	35	72	36	79	154	76
NHT°C	4	17	7	1	0	1	NHT°C	109	209	106	11	25	11
GT°C	8	13	2	2	2	3	GT°C	79	176	88	30	62	29
SIC	5	13	4	3	5	1	SIC	67	136	68	51	104	54
IAR	5	3	1	5	13	2	IAR	39	85	43	71	141	73
Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Epidemics +/-epizootics, 1500-													
Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	3	3	1	1	0	1	SSN	49	100	51	27	56	27
GSSN	3	9	2	0	1	0	GSSN	63	136	68	31	62	31
TSI	6	5	3	0	1	0	TSI	67	140	70	30	57	30
CRI	0	0	0	5	4	0	CRI	13	33	14	53	127	59
MeV	5	5	3	0	3	2	MeV	64	134	66	56	110	54
Be10	2	4	0	5	6	1	Be10	36	72	38	77	159	81
NHT°C	7	6	5	0	0	0	NHT°C	106	220	108	12	25	12
GT°C	3	10	4	0	0	1	GT°C	84	179	86	32	64	31
SIC	1	8	2	1	2	4	SIC	71	141	70	53	107	51
IAR	0	2	1	6	5	4	IAR	44	86	43	70	149	71

(B) Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Cat.A&B, 1700-

Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	8	9	2	4	9	2	SSN	44	94	50	24	47	26
GSSN	4	12	5	3	9	1	GSSN	31	86	61	27	48	29
TSI	4	6	3	15	6	NA	TSI	26	52	27	115	65	NA
CRI	1	2	3	7	14	6	CRI	12	31	11	51	117	53
MeV	2	8	2	6	10	5	MeV	10	68	37	45	74	35
Be10	3	7	2	5	10	5	Be10	21	45	25	44	77	42
NHT°C	3	19	9	1	0	1	NHT°C	26	129	66	11	25	11
GT°C	9	17	2	1	1	3	GT°C	52	116	27	26	26	14
SIC	5	15	4	3	6	1	SIC	27	65	40	39	75	31
IAR	4	4	0	7	14	3	IAR	20	51	28	37	79	39

Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Cat.A, 1700-

Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	5	7	2	4	9	1	SSN	47	96	50	24	47	27
GSSN	3	8	4	3	9	1	GSSN	32	90	62	27	48	29
TSI	4	6	3	11	4	NA	TSI	26	52	27	119	67	NA
CRI	1	2	3	2	13	6	CRI	12	31	11	56	118	53
MeV	0	6	1	6	9	5	MeV	12	70	38	45	75	35
Be10	3	5	2	2	9	5	Be10	21	47	25	47	78	42
NHT°C	0	17	8	1	0	1	NHT°C	29	131	67	11	25	11
GT°C	7	13	2	1	1	3	GT°C	54	120	27	26	26	14
SIC	4	13	3	3	4	1	SIC	28	67	41	39	77	31
IAR	4	2	0	5	13	2	IAR	20	53	28	39	80	40

Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Pandemics +/-epizootics, 1700-

Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	5	6	1	3	9	1	SSN	47	97	51	25	47	27
GSSN	3	7	3	3	8	1	GSSN	32	91	63	27	49	29
TSI	4	5	3	10	3	NA	TSI	26	53	27	120	68	NA
CRI	1	2	3	2	10	6	CRI	12	31	11	56	121	53
MeV	0	5	1	6	9	3	MeV	12	71	38	45	75	37
Be10	3	4	2	2	7	5	Be10	21	48	25	47	80	42
NHT°C	0	16	6	1	0	1	NHT°C	29	132	69	11	25	11
GT°C	7	11	1	1	1	3	GT°C	54	122	28	26	26	14
SIC	4	10	3	3	4	1	SIC	28	70	41	39	77	31
IAR	4	2	0	3	12	2	IAR	20	53	28	41	81	40

Number of outbreak years (event) and non-outbreak years by +ve and -ve quartiles (R results): Epidemics +/-epizootics, 1700-

Variable anomalies	Event large -ve	Event medium -ve	Event small -ve	Event large +ve	Event medium +ve	Event small +ve	Variable anomalies	No event large -ve	No event medium -ve	No event small -ve	No event large +ve	No event medium +ve	No event small +ve
SSN	3	3	1	1	0	1	SSN	49	100	51	27	56	27
GSSN	1	5	2	0	1	0	GSSN	34	93	64	30	56	30
TSI	0	1	0	5	3	NA	TSI	30	57	30	125	68	NA
CRI	0	0	0	5	4	0	CRI	13	33	14	53	127	59
MeV	2	3	1	0	1	2	MeV	10	73	38	51	83	38
Be10	0	3	0	3	3	0	Be10	24	49	27	46	84	47
NHT°C	3	3	3	0	0	0	NHT°C	26	145	72	12	25	12
GT°C	2	6	1	0	0	0	GT°C	59	127	28	27	27	17
SIC	1	5	1	0	2	0	SIC	31	75	43	42	79	32
IAR	0	2	0	4	2	1	IAR	24	53	28	40	91	41

Tables **(A)** from 1500-, and **(B)** from 1700-, provide the numbers of outbreak (event) and non-outbreak (event) years by positive and negative quartile for each independent variable and outbreak category. These results were generated by R, and were used to derive the Chi-square and Fisher's exact tests of independence results in S10 Table. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S12: Multiple logistic regression best model results (stepwise, backward method).

Stepwise Model Parameters	MAV period= 11							
Cat. A&B	VIF	Estimate	SE	Z value	Pr(>|z|)	AIC	R2	N
Intercept		-2.7	0.4	-6.4	0.00	150.8	0.03	219
10Be anom.	3.7							
CRI anom.	12.3							
MeV anom.	3.0							
TSI anom.	3.7							
NHT°C anom.	14.5							
GT°C anom.	5.2							
SIC anom.	3.0	-0.9	0.6	-1.4	0.16			
IAR anom.	1.3							
SSN_dummy_P+T	1.0	1.0	0.5	2.0	0.04			
Avg. VIF	5.3							

Stepwise Model Parameters	MAV period= 9							
Cat. A	VIF	Estimate	SE	Z value	Pr(>|z|)	AIC	R2	N
Intercept		-3.0	0.5	-6.6	0.00	135.4	0.02	229
10Be anom.	2.9							
CRI anom.	7.4							
MeV anom.	2.5							
TSI anom.	3.3							
NHT°C anom.	9.6							
GT°C anom.	4.3							
SIC anom.	3.2							
IAR anom.	1.4							
SSN_dummy_P+T	1.0	1.1	0.5	2.0	0.049			
Avg. VIF	4.0							

Stepwise Model Parameters	MAV period= 10							
Pan*	VIF	Estimate	SE	Z value	Pr(>|z|)	AIC	R2	N
Intercept		-3.2	0.5	-6.3	0.00	124.5	0.02	224
10Be anom.	3.0							
CRI anom.	8.3							
MeV anom.	2.7							
TSI anom.	3.5							
NHT°C anom.	11.2							
GT°C anom.	4.9							
SIC anom.	3.2							
IAR anom.	1.4							
SSN_dummy_P+T	1.0	1.2	0.6	2.0	0.04			
Avg. VIF	4.4							

Stepwise Model Parameters	MAV period= 11							
Cat. B	VIF	Estimate	SE	Z value	Pr(>|z|)	AIC	R2	N
Intercept		-16.7	6.7	-2.5	0.01	31.5	0.08	219
10Be anom.	93.3	-9.2	5.9	-1.6	0.12			
CRI anom.	634.3	23.7	11.3	2.1	0.04			
MeV anom.	158.7							
TSI anom.	29.6	-15.8	9.5	-1.7	0.10			
NHT°C anom.	34.6							
GT°C anom.	61.2							
SIC anom.	10.9							
IAR anom.	10.8	168.9	88.2	1.9	0.06			
SSN_dummy_P+T	2.1							
Avg. VIF	115.1							

Stepwise Model Parameters	MAV period= 11							
Epi*	VIF	Estimate	SE	Z value	Pr(>|z|)	AIC	R2	N
Intercept		-5.6	1.4	-4.1	0.00	52.5	0.06	219
10Be anom.	22.4	-8.5	4.6	-1.8	0.07			
CRI anom.	29.9							
MeV anom.	7.9	0.0	0.0	-2.2	0.03			
TSI anom.	9.4	-12.9	6.5	-2.0	0.046			
NHT°C anom.	32.2							
GT°C anom.	8.0	-1.9	1.1	-1.7	0.10			
SIC anom.	4.5							
IAR anom.	2.2	90.3	54.1	1.7	0.10			
SSN_dummy_P+T	1.2							
Avg. VIF	13.1							

Multiple logistic regression best model summary results for each outbreak category comprising ≥1 significant predictor ($Pr(>|z|)<0.05$) and any associated marginal predictors ($Pr(>|z|)<0.2$), estimates of the β coefficients (positive or negative impact on outbreak probability), standard errors (SE), Z-values, Akaike information criteria (AIC), Cox Snell pseudo-R-squared, and variance inflation factor (VIF) data. Best models had the lowest AIC value in their category and ≥1 significant predictor ($Pr(>|z|)<0.05$) +/- marginal predictors. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S13. Multiple logistic regression and variance inflation factor results summary (All-models).

(A) Stepwise Models:	Pr>|z| <0.05	Pr>|z| <0.2	Pr>|z| <0.05	Pr>|z| <0.2	Pr>|z| <0.05	Pr>|z| <0.2	Pr>|z| <0.05	Pr>|z| <0.2	Pr>|z| <0.05	Pr>|z| <0.2	All Pr>|z| <0.05	All Pr>|z| <0.2	All Pr>|z| <0.05	All Pr>|z| <0.05	All Pr>|z| <0.2	All Pr>|z| <0.05	All Pr>|z| <0.2
Outbreak category	Cat. A&B	Cat. A&B	Cat. A	Cat. A	Pan*	Pan*	Epi*	Epi*	Cat. B	Cat. B	Total No.# IVs	Total No.# IVs	All outbr eaks	Cat A&B, A,	Cat A&B, A,	Cat B, Epi*	Cat B, Epi*
No.# model intercepts	11		11		11		11		11		55						
10Be anom.				1		2		1		1	0	5		0%	4%	0%	5%
CRI anom.	4	6		1			10	10	10	11	24	28	44%	12%	9%	91%	53%
MeV anom.							1	1		5	1	6	2%	0%	0%	5%	15%
TSI anom.	2	4	2	2		2	1	1		1	5	10	9%	12%	10%	5%	5%
NHT°C anom.	2	3	1	4				1		2	3	10	5%	9%	9%	0%	8%
GT°C anom.		3		1		1		1			0	6		0%	6%	0%	3%
SIC anom.	2	5	5	5	1	4					8	14	15%	24%	18%	0%	0%
IAR anom.	1	3		2				3		2	1	10	2%	3%	6%	0%	13%
SSN_dummy_P+T	4	9	3	11	6	11					13	31	24%	39%	39%	0%	0%
Total variables	15	33	11	27	7	20	12	18	10	22	55	120	100%	100%	100%	100%	100%
Avg. # variables / model	1.4	3.0	1.0	2.5	0.6	1.8	1.1	1.6	0.9	2.0	1.0	2.2					

(B) Average variance inflation factor (VIF)	N	Be10	CRI anom.	MeV anom.	TSI anom.	NHT°C anom.	GT°C anom.	SIC anom.	IAR anom.	SSN dummy	**Avg. category**
Cat. A&B	11	2.7	8.0	2.5	3.2	8.4	3.8	2.1	1.2	1.1	**3.7**
Cat. A	11	2.5	6.3	2.4	3.3	7.6	3.9	2.5	1.2	1.1	**3.4**
Pan*	11	2.4	6.1	2.4	3.3	7.2	3.8	2.4	1.2	1.1	**3.3**
Cat. B	11	15.3	164.6	49.9	6.3	20.3	18.4	3.9	3.7	1.5	**31.5**
Epi*	11	6.1	18.2	3.5	3.1	19.4	5.0	2.5	1.6	1.2	**6.7**
All variables		**5.8**	**40.6**	**12.1**	**3.9**	**12.6**	**7.0**	**2.7**	**1.8**	**1.2**	**9.7**

(A) This All-model summary comprises all stepwise models (backward method) with ≥1 significant predictor (Pr(>|z|)<0.05), and their associated marginal predictors (Pr(>|z|)<0.2), by outbreak category (Cat.A&B, Cat.A, pandemics +/-concurrent epizootics or Pan*, epidemics +/- concurrent epizootics or Epi*, and Cat.B). Outbreak and predictor category totals highlight the relative dominance of predictors, and the contrasting differences between pandemic and epidemic outbreak categories. **(B)** An All-model summary of the variance inflation factor (VIF) data highlights an issue with multi-collinearity. A VIF>10 was considered problematic, a VIF>5 was highly correlated, and a VIF>2.5 was moderately correlated. See the readme file (Figshare) for a detailed description of the methodology. Data citations: Outbreak database expert reviews [1]–[7]. Independent variable data [8]–[16].

Table S14. Basic statistical analyses results for independent variables (outbreak risk factors).

Independent Variable	N (years)	Mean	SD	Median	Min	Max	Skew	Kurtosis	SE	Lower 95% CI	Upper 95% CI
Sunspot number (SSN)	319	79	62	66	0	269	0.8	-0.1	3.5	72.2	85.8
Group sunspot number (GSSN)	406	3.8	3.1	2.8	0.1	13.0	0.8	-0.4	0.2	3.5	4.1
Total solar irradiance (TSI)	409	1361	0.47	1361	1360	1362	0.25	-0.58	0.02	1360.9	1361.0
TSI anomaly [W/m^2]	409	-0.25	0.47	-0.25	-1.05	1.13	0.25	-0.58	0.02	-0.30	-0.21
Cosmic ray intensity (CRI)	308	4.3	0.2	4.3	3.6	4.8	-0.26	-0.18	0.01	4.2	4.3
CRI anomaly [N (10^4 counts/hour)]	308	0.2	0.2	0.2	-0.5	0.7	-0.26	-0.18	0.01	0.20	0.25
Solar modulation function (MeV) anomaly	502	0.0	234	-33	-386	969	0.89	1.02	10.44	-20.5	20.5
Beryllium10 concentration (Be10)	481	1.8	0.5	1.7	0.8	3.8	1.28	2.41	0.02	1.7	1.8
Be10 conc. anomaly (x10^4 atoms)	481	0.25	0.48	0.15	-0.75	2.29	1.28	2.41	0.02	0.21	0.29
NH.Temperature anomaly (^{0}C)	501	-0.41	0.24	-0.41	-0.96	0.15	0.36	0.06	0.01	-0.43	-0.39
Greenland temperature	494	-31.7	0.6	-31.8	-32.9	-29.8	0.66	0.19	0.03	-31.8	-31.7
Greenland temp anomaly (^{0}C)	494	-0.3	0.6	-0.3	-1.5	1.7	0.66	0.19	0.03	-0.33	-0.22
Arctic sea ice cover proxy (SIC) anomaly	511	-0.1	0.6	-0.1	-1.9	1.3	0.08	-0.24	0.03	-0.14	-0.04
Ice accummulation rate	481	0.2	0.0	0.2	0.1	0.3	-0.32	0.61	0.00	0.19	0.20
Ice acc. rate anomaly (m ice/yr)	481	0.0	0.0	0.0	-0.1	0.2	-0.32	0.61	0.00	0.01	0.01

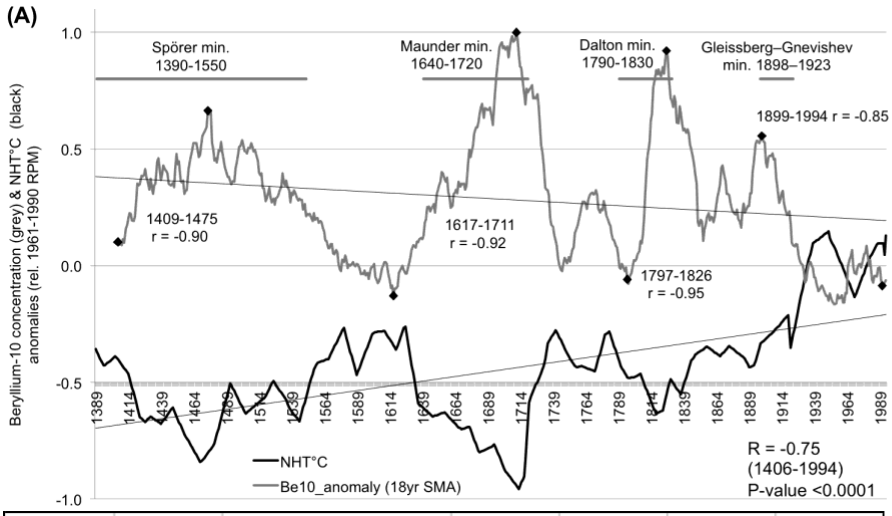
Basic statistical parameters were calculated in Excel from the raw and anomaly data. Both ^{10}Be and IAR (same dataset) had 14 years of missing data (in their 495 year data series, 1500-). A detailed description of the missing data and how this was managed is explained in the readme notes available online (Figshare). Data citations [8]–[16].

Table S15. Correlation coefficients between solar activity and climate change outbreak predictors.

SMA period (years)	(1) CRI v GMA-AA	(2) CRI v NHT°C	(3) CRI v GT°C	(4) CRI v SIC	(5) GMA-AA v 10Be	(6) 10Be v NHT°C	(7) 10Be v GT°C	(8) SSN v CRI	(9) GMA-AA index v IAR	(1) CRI v 10Be	(2) GMA-AA v NHT°C	(3) GMA-AA v GT°C	(4) GMA-AA v SIC	(5) GT°C v NHT°C	(6) GT°C v SIC	(7) TSI v NHT°C	(8) SSN v GMA-AA	(9) SSN v NHT°C
1	-0.74	-0.68	-0.44	-0.34	-0.27	-0.47	-0.28	-0.68	-0.16	0.49	0.60	0.25	0.32	0.50	0.30	0.52	0.57	0.28
2	-0.77	-0.70	-0.44	-0.41	-0.37	-0.56	-0.33	-0.69	-0.24	0.58	0.64	0.26	0.40	0.50	0.35	0.53	0.59	0.29
3	-0.80	-0.71	-0.45	-0.45	-0.43	-0.60	-0.36	-0.70	-0.29	0.63	0.67	0.27	0.44	0.50	0.39	0.54	0.61	0.31
4	-0.82	-0.74	-0.46	-0.49	-0.49	-0.63	-0.38	-0.71	-0.32	0.66	0.71	0.28	0.48	0.50	0.42	0.56	0.63	0.33
5	-0.84	-0.77	-0.47	-0.53	-0.54	-0.66	-0.40	-0.72	-0.36	0.69	0.74	0.29	0.52	0.50	0.44	0.57	0.65	0.36
6	-0.86	-0.80	-0.48	-0.55	-0.58	-0.67	-0.41	-0.74	-0.42	0.71	0.78	0.30	0.56	0.51	0.45	0.59	0.68	0.41
7	-0.88	-0.83	-0.49	-0.57	-0.61	-0.69	-0.43	-0.75	-0.46	0.73	0.81	0.31	0.58	0.51	0.46	0.60	0.73	0.46
8	-0.90	-0.85	-0.50	-0.58	-0.64	-0.71	-0.44	-0.78	-0.50	0.75	0.84	0.32	0.60	0.51	0.47	0.61	0.79	0.52
9	-0.92	-0.87	-0.51	-0.60	-0.66	-0.72	-0.44	-0.80	-0.52	0.76	0.86	0.33	0.62	0.51	0.48	0.62	0.86	0.57
10	-0.94	-0.88	-0.51	-0.61	-0.69	-0.73	-0.45	-0.81	-0.54	0.76	0.87	0.34	0.63	0.52	0.49	0.63	0.90	0.61
11	-0.94	-0.88	-0.52	-0.62	-0.71	-0.74	-0.46	-0.82	-0.56	0.77	0.88	0.34	0.64	0.52	0.50	0.63	0.91	0.62
N (1-11yr)	140-130	301-291	294-284	308-298	126-106	481-385	480-384	308-298	126-106	286-220	133-123	126-116	143-133	494-484	494-484	391-381	143-133	301-291
P-values	all p<0.001	all p<0.001	all p<0.001	all p<0.001	p=0.01-<0.001	all p<0.001	all p<0.001	all p<0.001	p<0.01 2yr sma, p<0.001 4-11yr sma	all p<0.001	all p<0.001	p=0.01-<0.001	all p<0.001	all p<0.001	all p<0.001	all p<0.001	all p<0.001	all p<0.001
% Change in r from 1 to 11yr SMA	28%	29%	18%	83%	160%	57%	62%	20%	252%	56%	46%	39%	104%	4%	67%	21%	62%	118%
	Avg. correlation increase (-ve r)								79%	Avg. correlation increase (+ve r)								57%
	Avg. all correlation changes (+ & -)								68%									
	Avg. 1yr correlation (-ve r)								-0.45	Avg. 1yr correlation (+ve r)								0.43
	Avg. 11yr correlation (-ve r)								-0.70	Avg. 11yr correlation (+ve r)								0.65

Pearson correlation coefficients and P-values, and other results are provided for key solar-/geo-magnetism (esp. CRI, 10Be, GMA-AA) and solar electromagnetism variables (TSI), between themselves, and with terrestrial-derived climate change variables (NHT°C, GT°C, SIC, and IAR anomalies). These results demonstrate the impact of data smoothing on increasing the correlation coefficient values, which mirrors the trend with the variance inflation factor data for these same variables. The table is split into positive (N = 9 columns) and negative (N = 9 columns) correlation coefficients. A summary of the mean absolute and percentage increase in correlation coefficients from the raw data to the 11-year SMA are provided below each column. This data was used to create the publication Fig. 7. See the readme file (Figshare) for a detailed description of the methodology. Data citations [8], [10]–[17].

Figure S16. Northern Hemisphere temperature -v- 18yr SMA 10Be conc. anomalies (1406-1994).



(C)		NHT°C anomaly →					
	SMA (yrs)	1	11	18	24	30	36
Be10 conc.	1	-0.45	-0.44	-0.42	-0.40	-0.39	-0.37
anomaly	11	-0.74	-0.75				
↓	18	-0.75		-0.79			
	24	-0.72			-0.81		
	30	-0.69				-0.82	
	36	-0.66	Pearson correlation coefficients				-0.822

(A) This figure depicts a linear plot between the NHT°C raw data and an 18-year SMA ^{10}Be concentration anomaly. This graphic is annotated with period-specific Pearson correlation coefficients relevant to the whole period (1406-1994, r=-0.75), to three of the Little Ice Age's (LIA) numerous grand solar minimum periods (Spörer, Maunder, and Dalton), and from the beginning of the Gleissberg–Gnevishev minimum (1898-1923) that straddled the deadliest influenza pandemic on record (1918-20) to after the 1961-1990 RPM. These co-plotted variables' decadal- to centennial-scale oscillations also counter-tracked each other through both cold and warm climate phases, including through the industrial-modern era (1899-1994, r=-0.85). All LIA grand solar minimum periods paralleled a sustained NHT°C cooling period. **(B)** Figure A converted into a scatter plot and annotated with a trend line, slope equation and R-squared value. **(C)** A series of Pearson correlation coefficients were derived for multiple permutations of the raw data and trailing simple moving average periods for both variables (11, 18, 24, 30, and 36 years). This analysis was used to select the 18-year SMA ^{10}Be concentration anomaly versus NHT°C raw data for plotting (quasi-optimized correlation), and demonstrated the impact of data smoothing. This smoothing was used to proxy a potential sustained cause (^{10}Be, solar-heliospheric-magnetospheric magnetism controlled) and effect

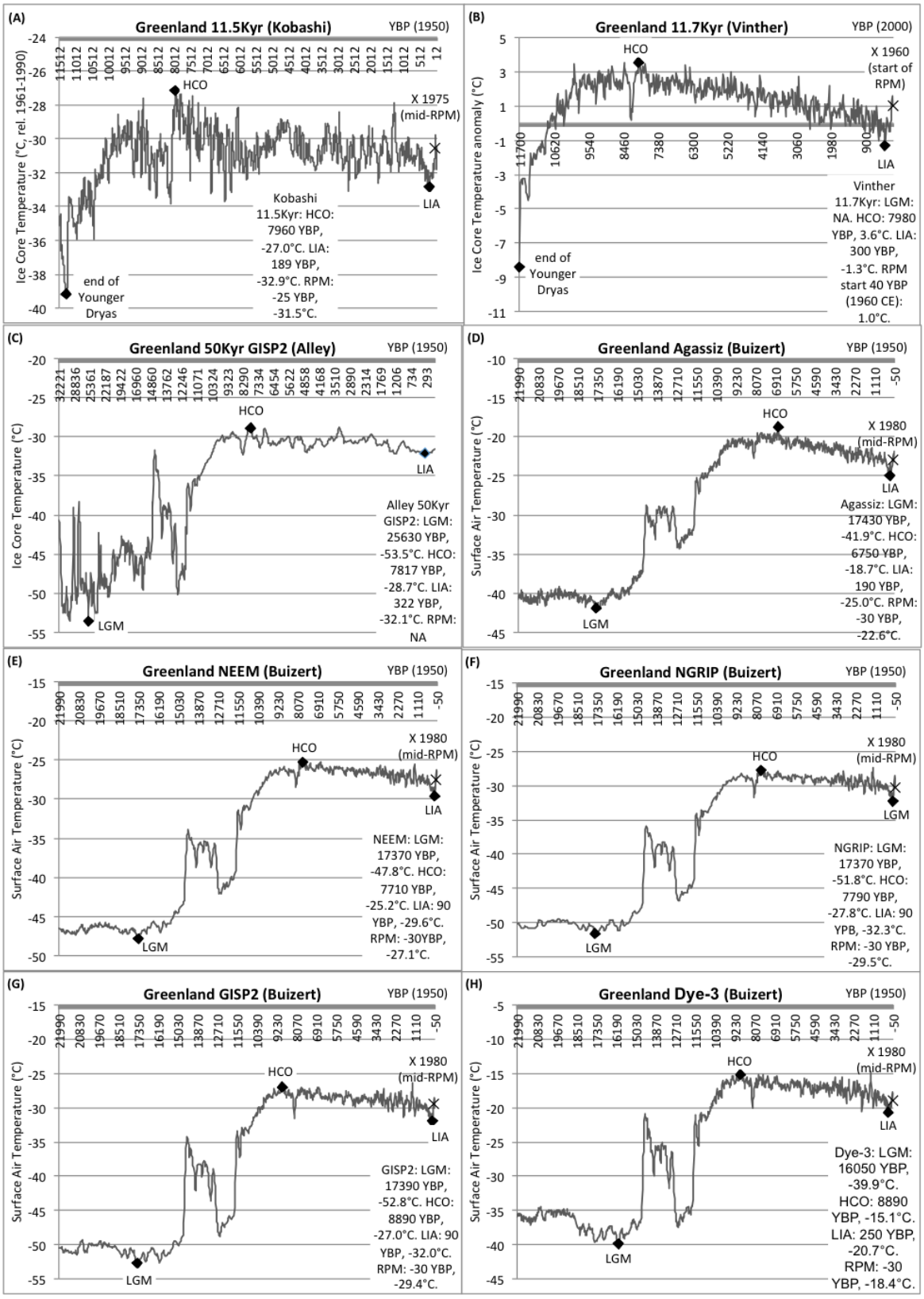
(NHT°C, terrestrially derived from Greenland ice core raw data). See the readme file (Figshare) for a detailed description of the methodology. Data citations [13], [14].

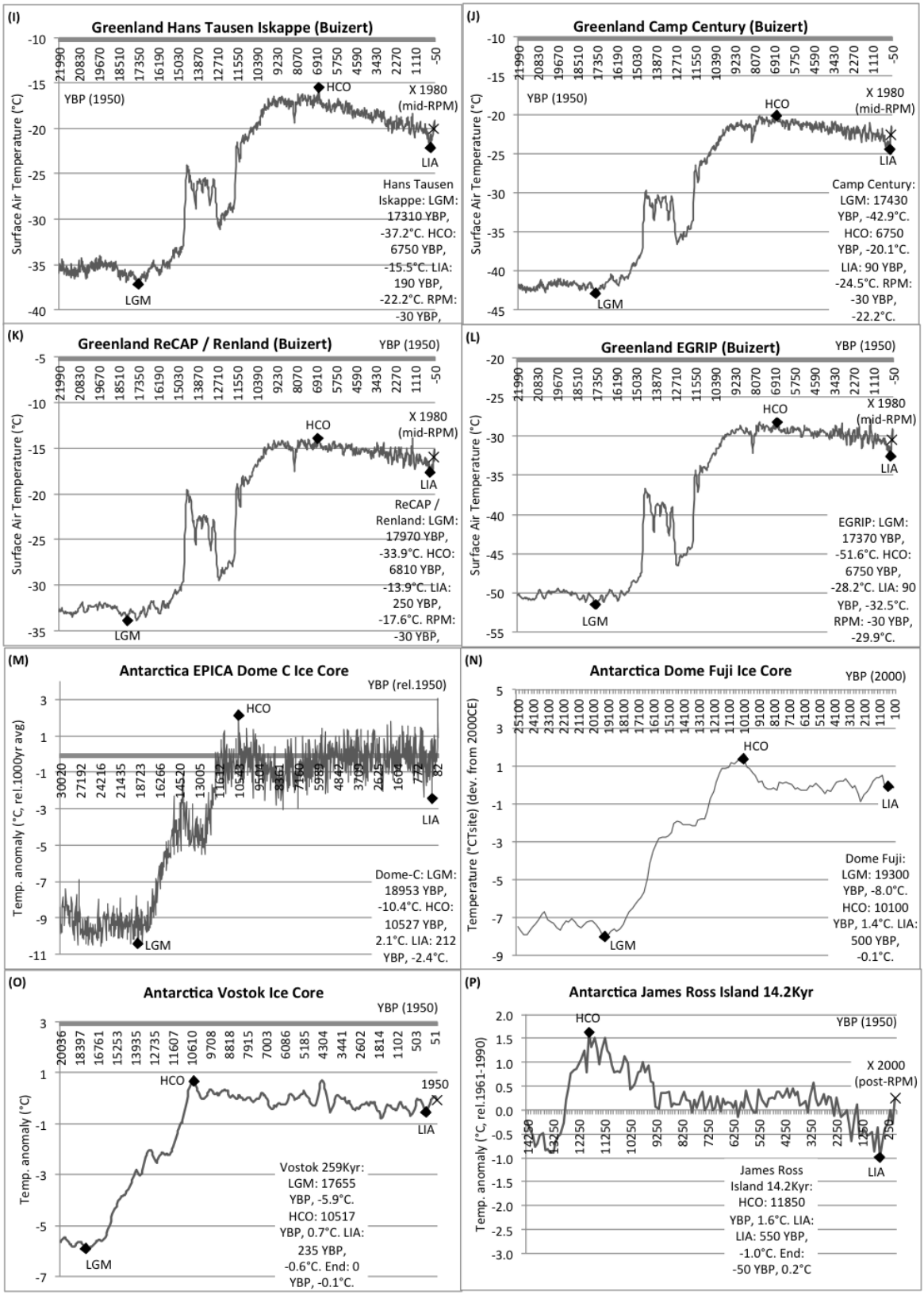
Table S17. Re-calibrated risk factor mid-study period relative to the Holocene Climate Optimum.

BCE -ve / CE +ve	LGM (BCE-)	HCO (BCE-)	LIA temp. nadir (CE+/ BCE-)	RPM closest year (CE+)	End of data series (CE+)	LGM-to-HCO: Interglacial duration (years)	HCO-to-LIA yrs: new Ice Age Duration (mid-study)	HCO-to-RPM: new Ice Age duration (to 1975 or 1980)	HCO-to-end of data: new Ice Age duration	LGM (temp. or anomaly °C)	HCO (temp. or anomaly °C)	LIA temp. nadir (temp. or anomaly °C)	RPM temp or anomaly (°C)	End of data temp or anomaly (°C)	LGM-to-HCO: Interglacial temp. rise (°C)	HCO-to-LIA°C: temp. decline since peak HCO (°C)	HCO-to-RPM: temp. decline since peak HCO (°C)	HCO-to-Data end: temp. decline since peak HCO (°C)	LIA-to-RPM: temp. increase to RPM or end of data (°C)	HCO-LIA Δ°C ÷ HCO-LGM Δ°C = Ice Age Entry % to LIA temp. nadir	HCO-to-RPM or -Data end Δ°C ÷ HCO-LGM Δ°C = Ice Age Entry % by RPM/Data end
ANTARCTICA																					
Dome-C	-17003	-8577	1738	NA	1912	8,426	10,315	NA	10,489	-10.4	2.1	-2.4	NA	0.9	12.6	-4.6	NA	-124%	NA	-36%	-10%
Dome Fuji	-17300	-8100	1500	NA	1900	9,200	9,600	NA	10,000	-8.0	1.4	-0.1	NA	-0.2	9.4	-1.5	NA	-151%	NA	-15%	-16%
James Ross Island	NA	-9900	1400	NA	2000	NA	11,300	NA	11,900	NA	1.6	-1.0	NA	0.2	NA	-2.6	NA	-138%	NA	NA	NA
Vostok	-15705	-8567	1715	NA	1950	7,138	10,282	NA	10,517	-5.9	0.7	-0.6	NA	-0.1	6.6	-1.3	NA	-76%	NA	-19%	-11%
ARCTIC (GREENLAND)																					
GT°C (Kobashi)	NA	-6010	1761	1975	1993	NA	7,771	7,985	8,003	NA	-27.0	-32.9	-31.5	-30.5	NA	-5.9	-4.4	-3.5	1.5	NA	NA
Greenland (Vinther)	NA	-5980	1700	NA	1960	NA	7,680	NA	7,940	NA	3.6	-1.3	NA	1.0	NA	-4.9	NA	-2.5	NA	NA	NA
Greenland GISP2	-23680	-5867	1628	NA	1855	17,813	7,495	NA	7,722	-53.5	-28.7	-32.1	NA	-31.6	24.8	-3.4	NA	-2.9	NA	-14%	-12%
Greenland (9 site avg.)	-15349	-5504	1802	1980	2000	9844	7307	7,484	7,504	-44.4	-21.3	-26.3	-23.9	-23.2	23.1	-5.0	-2.6	-1.9	2.4	-21%	-8%
Std. Dev. (9 sites)	508	915	72	0	0	1292	920	915	915	6.9	5.8	5.6	5.3	5.3	1.7	1.0	1.0	1.0	0.3		
				RPM proxy: avg. 1960-2000=1980																	
NEEM	-15420	-5760	1860	1980	2000	9,660	7,620	7,740	7,760	-47.8	-25.2	-29.6	-27.1	-26.4	22.6	-4.4	-1.8	-1.2	2.6	-19%	-5%
NGRIP	-15420	-5840	1860	1980	2000	9,580	7,700	7,820	7,840	-51.8	-27.8	-32.3	-29.5	-28.8	24.0	-4.5	-1.7	-1.0	2.8	-19%	-4%
GISP2	-15440	-6940	1860	1980	2000	8,500	8,800	8,920	8,940	-52.8	-27.0	-32.0	-29.4	-28.8	25.8	-5.0	-2.4	-1.8	2.6	-19%	-7%
Dye-3	-14100	-6940	1700	1980	2000	7,160	8,640	8,920	8,940	-39.9	-15.1	-20.7	-18.4	-17.9	24.8	-5.6	-3.3	-2.8	2.3	-23%	-11%
ReCAP / Renland	-16020	-4860	1700	1980	2000	11,160	6,560	6,840	6,860	-33.9	-13.9	-17.6	-15.9	-15.2	19.9	-3.7	-2.0	-1.3	1.7	-19%	-6%
Agassiz	-15480	-4800	1760	1980	2000	10,680	6,560	6,780	6,800	-41.9	-18.7	-25.0	-22.6	-21.9	23.2	-6.2	-3.9	-3.2	2.4	-27%	-14%
Hans Tausen Iskappe	-15360	-4800	1760	1980	2000	10,560	6,560	6,780	6,800	-37.2	-15.5	-22.2	-19.7	-19.1	21.7	-6.7	-4.2	-3.6	2.4	-31%	-17%
Camp Century	-15480	-4800	1860	1980	2000	10,680	6,660	6,780	6,800	-42.9	-20.1	-24.5	-22.2	-21.6	22.8	-4.4	-2.1	-1.5	2.3	-19%	-6%
EGRIP	-15420	-4800	1860	1980	2000	10,620	6,660	6,780	6,800	-51.6	-28.2	-32.5	-29.9	-29.3	23.3	-4.3	-1.7	-1.0	2.6	-18%	-4%

Immutable glacial cycle landmark temperatures and their changes and intervals are provided for 16 polar ice cores, which were used to benchmark and re-calibrate this risk factor study's GT°C temperature data relative to the glacial cycle's maximum and minimum temperatures versus the 1961-1990 RPM. This data was extracted from the datasets cited below and is graphically depicted in its entirety in S18 Figure A-P. The ice age entry percentage (right shaded column) corresponds to the temperature anomaly decline between the Holocene Climate Optimum (HCO) and the Little Ice Age temperature nadir (LIA, mid-study), divided by the Holocene interglacial temperature increase between the Last Glacial Maximum (LGM) and HCO. For analytical purposes, temperatures were measured from their deepest troughs to their tallest peaks. The Holocene interglacial period represented the period between the LGM and HCO, which corresponded with the interval between the last glacial cycle's coldest temperature (LGM) and this glacial cycle's hottest temperature (HCO). In Greenland the Little Ice Age temperature nadir was invariably the coldest temperature after the HCO peak temperature (except Kobashi [16]). See the readme file (Figshare) for a detailed description of the methodology. Ice core data citations [16], [18]–[24].

Figure S18. Sixteen polar ice core temperature plots delineating key glacial cycle landmark dates.




(I)
Greenland Hans Tausen Iskappe (Buizert)
Surface Air Temperature (°C)
YBP (1950)
HCO
X 1980 (mid-RPM)
LIA
LGM
Hans Tausen Iskappe: LGM: 17310 YBP, -37.2°C. HCO: 6750 YBP, -15.5°C. LIA: 190 YBP, -22.2°C. RPM: -30 YBP,
(J)
Greenland Camp Century (Buizert)
Surface Air Temperature (°C)
YBP (1950)
HCO
X 1980 (mid-RPM)
LIA
LGM
Camp Century: LGM: 17430 YBP, -42.9°C. HCO: 6750 YBP, -20.1°C. LIA: 90 YBP, -24.5°C. RPM: -30 YBP, -22.2°C.
(K)
Greenland ReCAP / Renland (Buizert)
YBP (1950)
Surface Air Temperature (°C)
HCO
X 1980 (mid-RPM)
LIA
LGM
ReCAP / Renland: LGM: 17970 YBP, -33.9°C. HCO: 6810 YBP, -13.9°C. LIA: 250 YBP, -17.6°C. RPM: -30 YBP,
(L)
Greenland EGRIP (Buizert)
YBP (1950)
Surface Air Temperature (°C)
HCO
X 1980 (mid-RPM)
LIA
LGM
EGRIP: LGM: 17370 YBP, -51.6°C. HCO: 6750 YBP, -28.2°C. LIA: 90 YBP, -32.5°C. RPM: -30 YBP, -29.9°C.
(M)
Antarctica EPICA Dome C Ice Core
YBP (rel.1950)
Temp. anomaly (°C, rel.1000yr avg)
HCO
LIA
LGM
Dome-C: LGM: 18953 YBP, -10.4°C. HCO: 10527 YBP, 2.1°C. LIA: 212 YBP, -2.4°C.
(N)
Antarctica Dome Fuji Ice Core
YBP (2000)
Temperature (°CTsite) (dev. from 2000CE)
HCO
LIA
LGM
Dome Fuji: LGM: 19300 YBP, -8.0°C. HCO: 10100 YBP, 1.4°C. LIA: 500 YBP, -0.1°C.
(O)
Antarctica Vostok Ice Core
YBP (1950)
Temp. anomaly (°C)
HCO
1950
LIA
LGM
Vostok 259Kyr: LGM: 17655 YBP, -5.9°C. HCO: 10517 YBP, 0.7°C. LIA: 235 YBP, -0.6°C. End: 0 YBP, -0.1°C.
(P)
Antarctica James Ross Island 14.2Kyr
HCO
YBP (1950)
X 2000 (post-RPM)
Temp. anomaly (°C, rel.1961-1990)
LIA
James Ross Island 14.2Kyr: HCO: 11850 YBP, 1.6°C. LIA: LIA: 550 YBP, -1.0°C. End: -50 YBP, 0.2°C

Annotated temperature plots from 16 polar ice cores spanning key glacial cycle landmark dates-temperatures, including the Last Glacial Maximum (LGM), Holocene Climate Optimum (HCO), Little Ice Age (LIA) temperature nadir, and the mid climate reference period mean (1961-1990 RPM) or its nearest proxy. For analytical-descriptive purposes the glacial cycle peak temperature closest to the end of the prolonged-steep interglacial temperature rise was termed the Holocene Climate Optimum (HCO); the lowest post-HCO temperature trough during the LIA period (mid-13th to mid-19th centuries) was termed the Little Ice Age temperature nadir. The lowest glacial cycle temperature trough reached at the end of the last glacial cycle immediately prior to the sustained interglacial temperature rise was termed the Last Glacial Maximum (LGM). The Holocene interglacial was the period between the LGM and HCO. The new ice age was the period after the HCO peak temperature and period. See the readme file (Figshare) for a detailed description of the methodology. Ice core data citations [16], [18]–[24].

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